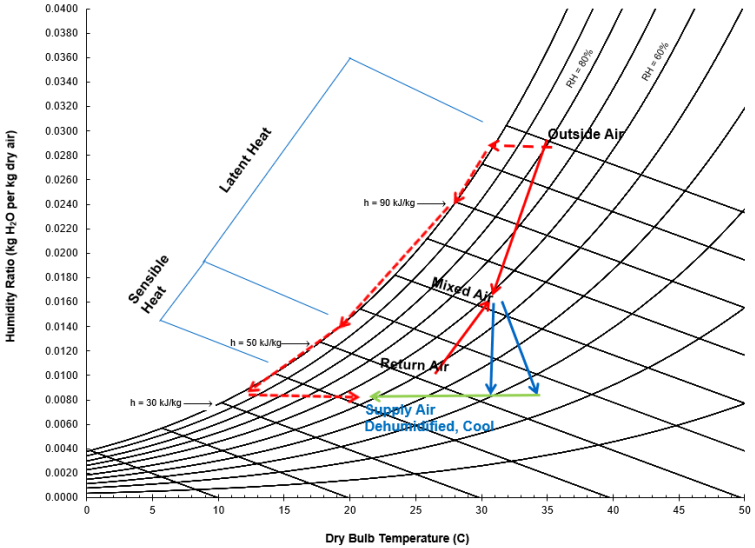
U.S. DEPARTMENT OF ENERGY

Office of ENERGY EFFICIENCY & RENEWABLE ENERGY

Novel Solar Absorption Cooling System to Reduce Peak Loads



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Project Summary

Timeline:

Start date: Oct 01, 2017

Planned end date: 9/30/2020

Key Milestones:

1. Suitable LD for dehumidification; 6/30/2018
2. Demonstrate the technology; 9/30/2018

Key Partners:

None	

Budget:

Total Project $ to Date:

- DOE: $200K
- Cost Share: $0

Total Project $:

- DOE: $500K
- Cost Share: $0

Project Outcome:

Liquid Desiccants (LDs) can store dehumidification capacity indefinitely without the need for any thermal insulation. Stored dehumidification capacity is equivalent to air-conditioning capacity, to be used on demand(BTO MYPP FY 2016-2020, pp. 62-63).

Team

- Within DOE, the Buildings Technologies Research and Integration Center (BTRIC) at ORNL is the Center of Excellence in Commercial and Residential building equipment R&D.
  - Focus to improve the efficiency in major areas of building energy use.
  - BTRIC research addresses 53% of primary energy use in buildings.
- BTRIC research infrastructure:
  - 3 sets of environmental chambers
  - 1 appliance chamber
  - controlled refrigerant test loop
  - compressor calorimeters of varying capacities
  - advanced modeling capabilities (Computational Fluid Dynamics, Heat Pump Design Model, and SorpSim)
  - natural gas calorimeter
  - additive manufacturing
  - access to neutron imaging
  - and controlled field tests.

- ORNL has strong product development projects with the leading U.S manufacturers like Whirlpool, General Electric, AO Smith, Lennox, Unico, Inc.

Team (cont'd)

- Active research areas:
  - commercial integrated heat pumps with thermal storage
  - commercial absorption water heaters
  - residential gas engine integrated heat pumps
  - electrochemical compressor
  - magnetic and membrane systems for air conditioning
  - cold climate heat pump
  - high efficiency roof top units
  - ground source heat pumps
  - data mining
  - alternate refrigerant evaluation
- Our international outreach is with the International Energy Agency (IEA) and the International Institute of Refrigeration (IIR).

Team (cont'd)

- BTRIC is credited with 22 ASHRAE Awards.
- Our Team earned the Peter Ritter von Rittinger Award by the IEA, May 2017.

Challenge

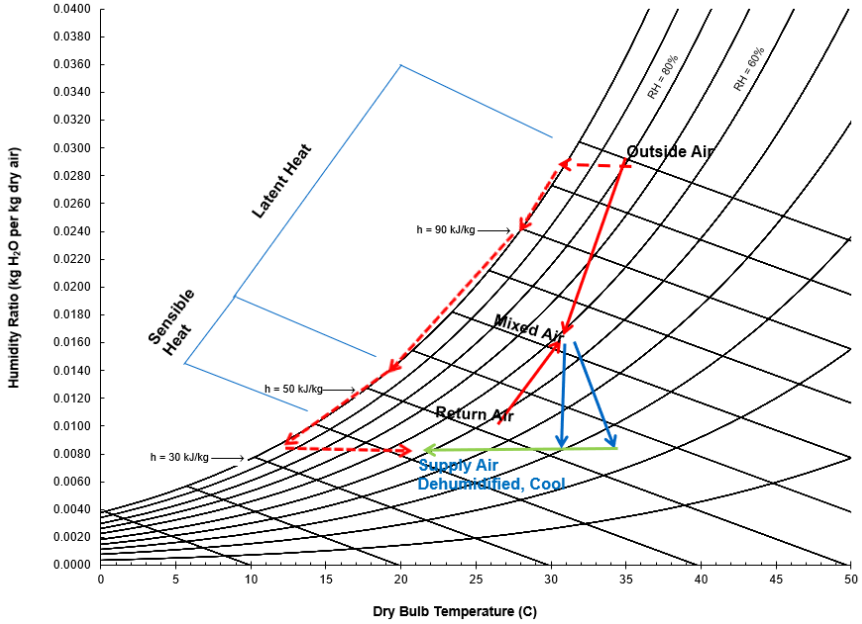
Problem Definition - Conventional dehumidification:

- Relies on cooling humid air below the dew point and then reheating the air to the comfort level or thermostatic set (TS) point.
- Humidity is not controlled.
- The HVAC system turns off when the set point temperature is reached even if the humidity remains elevated beyond a comfortable level. This pathway is energy intensive.
- A better way is to dehumidify the air using a LD to lessen the air-conditioning load.
- This would result in a smaller system and consume less primary energy.
- In hot-humid climates where air-conditioning loads are high, this *modus operandi* could remove approximately 70% of the latent load, the main culprit of energy consumption for the air-conditioning unit.
- Controlling the humidity shall result in a higher thermostatic temperature setting, better comfort level with less energy use.
- LD can provide meaningful HVAC load shifting.

Challenge (cont'd)

Advice:

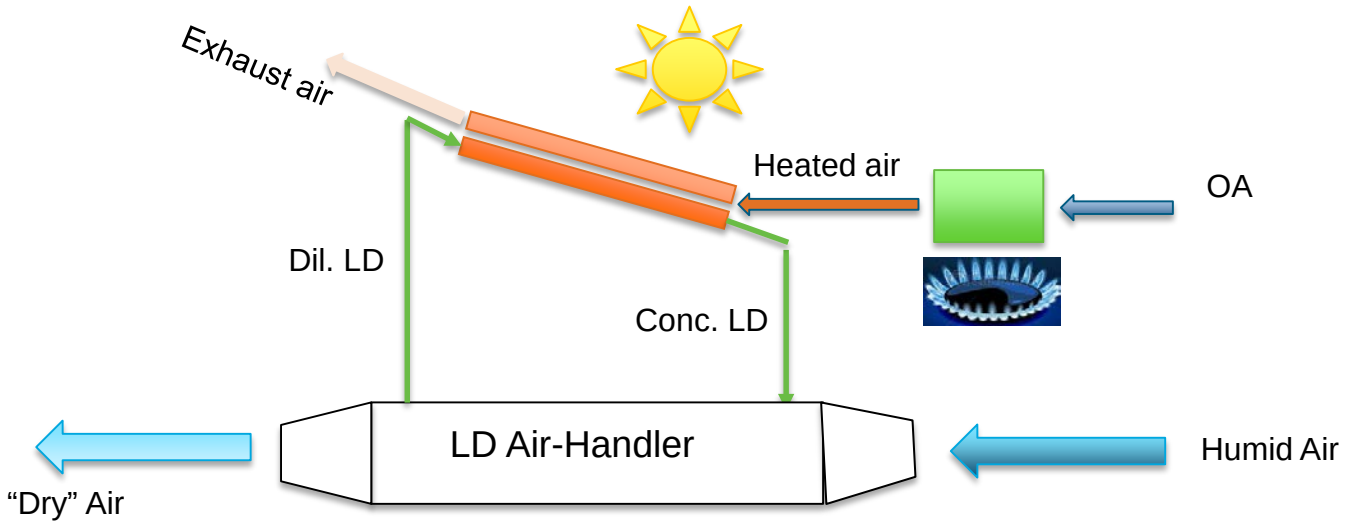
- In dry climates, elevated air temperatures (90°F) does not feel uncomfortable, whereas in humid climates even 75°F is uncomfortable.
- If the outdoor air (OA) can be pretreated to remove moisture, it will serve the dual benefit of providing comfort and saving energy.
- Fixation on TS temperature alone should be eschewed.
- Focus on humidity control first and TS setting later.
- Think about least energy pathway towards comfort.



Approach

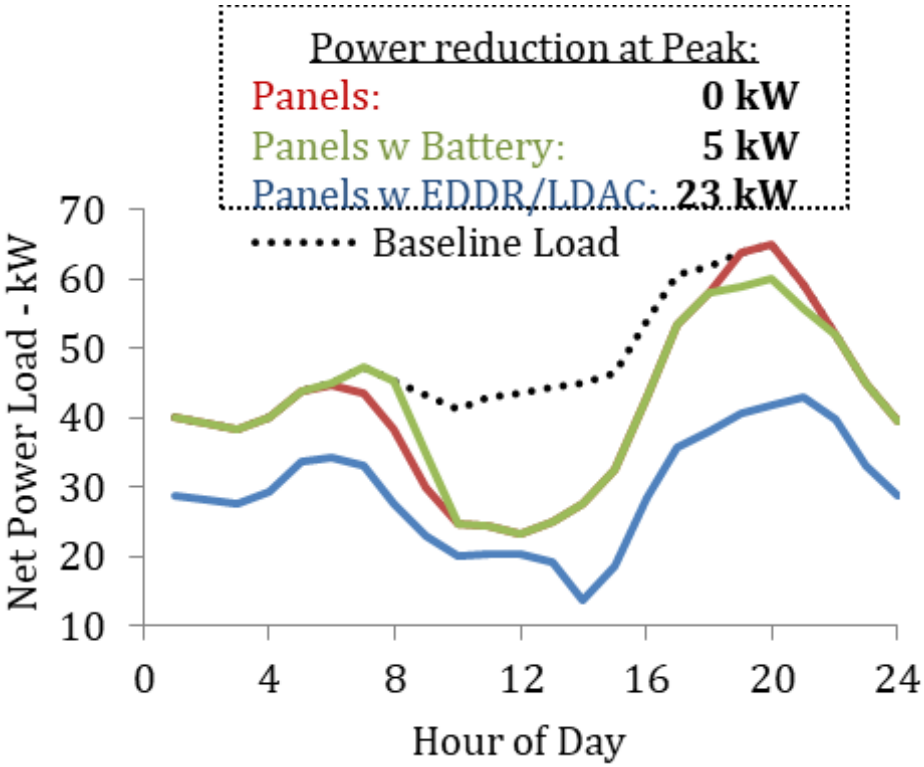
We are considering a couple of pathways of which one is an air-handler with a LD to remove humidity. The other is related to developing a fabric made of carbon Nano rods.

- These pathways are addressed by two separate projects started in FY18:
  - An air-handler with an inexpensive LD.
  - Regenerate the LD with solar energy, or solar supplemented with natural gas.
  - Other LD regeneration methods avoiding liquid/vapor phase change.
  - Development of laboratory prototypes to reduce idea to practice.



Approach (cont'd)

The LD system should also be valued (and evaluated) as a store of air-conditioning capacity. LD once generated can be stored indefinitely (without thermal insulation) and used when needed. This means they can be used to shift HVAC load.



- Mid-size apt. bldg., 25 ton-AC load in Palm Springs, CA.
- $3K worth of Tesla battery or LD system.
- Tesla Powerwall: $260/kWh (after 50% cost red).
- LD: $65/kWh
- LD is less expensive and can deliver more kW than Tesla at same cost.
- Relative size: Tesla: 44"x29"x5.5": LD 44" x29"x29" (160 gallons).
- Solar panel: 22kW for all options.

Approach (cont'd)

The carbon Nano-rod approach is a low (1) TRL project whereas the air-handler is a low-mid (3) level project.

- In the air-handler approach the barrier is to recover water without undergoing phase change. Overcoming the barrier shall be a quantum leap in dehumidification.
- Use more solar and less NG in certain climates.
- Use other regeneration techniques to avoid phase changes.

Impact

DOE MYPP 2016-2020 quantifies the energy savings of 50% with an integrated approach in HVAC. Dehumidification, especially in hot-humid climates is the major air-conditioning load.

- Traditional approach alluded to earlier has endured since the inception of HVAC, but it is energy intensive.
- The new approach is better because it aims to arrest humidity before it reaches the HVAC system.
  - For this, we need new materials and pathways for water recovery that avoid phase changes to reduce the energy burden.
  - Since heat and work are path dependent, new pathways to go from the initial to the final state points are required.
- Once the technology has achieved TRL 3-4 we shall be well-positioned to attract private capital, major manufacturers, and stakeholders to bring it to the marketplace.
  - The groundwork lies in reduction to practice.

Progress

- The proposed pathways have a sound basis in science and engineering.
- The challenge is to transform theory into practice.
- We are experimenting with a “model Ford” air handler that will provide us information on process parameters, flow rates, water removal rates, and LD inventory.
- In parallel, we are also performing simulations of using different desiccants for the natural gas-driven HVAC.
- Since project is a new start, the question of market risk can be assessed after completing the milestones.
- Prototype testing may be possible in the second year followed by field tests.
- Dissemination of information to stakeholders, conferences, and outreach of our Technology Transfer Office are avenues for engagement.
- The audience should care because energy savings go directly to the bottom line of individuals and corporations. Energy, national security, environment, competitiveness, and public health are interconnected.

Stakeholder Engagement

Key stake holders are OEMs, utilities. Licensing of technology is formalized through UT-Battelle, LLC Office of Technology Transfer.

- The market is trending towards distributed energy systems to make customers less grid dependent and improve reliability of commercial operations.
- Utilities are interested in any technology that will help serve their customer base in terms of performance and cost savings.
- Field demonstration of the technology shall follow development of IP portfolio and will involve interested OEMs.

Remaining Project Work

- The air-handler with solar-assisted dehumidification should be augmented to include other non-conventional techniques to regenerate the LD to improve process efficiency. This project is in early- to mid-stage of development.
- Our modeling effort is directed towards providing an assessment of the capabilities of different LDs to dehumidify air.
- Identify the markets and climates where this technology can make the greatest impact.
- Partner with utilities and customers for field demonstrations.
- Future work is to establish the technical and economic feasibility of demonstrating LD as a viable energy storage and peak load shifting technology for the commercial sector.
- Bring technology to the marketplace within 3 years.

Thank You

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REFERENCE SLIDES

Project Budget

Project Budget: Project started in FY 2018 ($200K)
Variances: No variances.
Cost to Date: Project expenditure is 44% of FY18 budget

Additional Funding: Note, if any, other funding sources.

Budget History					
10/01/2018 – FY 2017 (past)		FY 2018 (current)		FY 2019 – 9/30/2020 (planned)	
DOE	Cost-share	DOE	Cost-share	DOE	Cost-share
0	0	$200K	$0	$150K	$0K

Project Plan and Schedule

Describe the project plan including:

- Project original initiation date & Project planned completion date
- Schedule and Milestones
- Explanation for slipped milestones and slips in schedule
- Go/no-go decision points
- Current and future work

Project Start Date: 10/01/2018
Project End Date: 9/30/2020